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Fast Summed-Area Table Generation and its Applications

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Abstract

We introduce a technique to rapidly generate summed-area tables using graphics hardware. Summed area tables, originally introduced by Crow, provide a way to filter arbitrarily large rectangular regions of an image in a constant amount of time. Our algorithm for generating summed-area tables, similar to a technique used in scientific computing called recursive doubling, allows the generation of a summed-area table in O(log n) time. We also describe a technique to mitigate the precision requirements of summed-area tables. The ability to calculate and use summed-area tables at interactive rates enables numerous interesting rendering effects. We present several possible applications. First, the use of summed-area tables allows real-time rendering of interactive, glossy environmental reflections. Second, we present glossy planar reflections with varying blurriness dependent on a reflected object's distance to the reflector. Third, we show a technique that uses a summed-area table to render glossy transparent objects. The final application demonstrates an interactive depth-of-field effect using summed-area tables.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism: Color, shading, shadowing, and texture I.4.3 [Image Processing and Computer Vision]: Enhancement: Filtering

1. Introduction

There are many applications in computer graphics where spatially varying filters are useful. One example is the rendering of glossy reflections. Unlike perfectly reflective materials, which only require a single radiance sample in the direction of the reflection vector, glossy materials require integration over a solid angle. Blurring by filtering the reflected image with a support dependent on the surface's BRDF can approximate this effect. This is currently done by pre-filtering off line, which limits the technique to static environments.

Crow [Cro84] introduced summed-area tables to enable more general texture filtering than was possible with mip maps. Once generated, a summed-area table provides a means to evaluate a spatially varying box filter in a constant number of texture reads. Heckbert [Hec86] extended Crow's work to handle complex filter functions.

In this paper we present a method to rapidly generate summed-area tables that is efficient enough to allow multiple tables to be generated every frame while maintaining

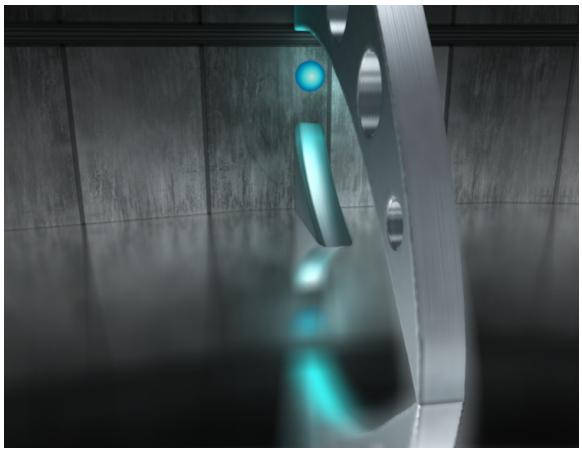

Figure 1: *An image illustrating the use of a summed-area table to render glossy planar reflections where the blurriness of an object varies depending on its distance from the reflector.*